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Investigation of high renewable energy penetration in the island of Syros following the interconnection with the national grid system

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Abstract

This paper aims to assess the potential of high renewable energy (wind and solar) integration in the Greek island of Syros, following the scheduled interconnection with the national grid system. Currently, Syros operates an oil fired autonomous power system (APS), emitting large amounts of carbon emissions. Interconnection among a number of islands in the Cyclades and the mainland will eliminate the use of APS, will reinforce islands' power network and will allow exploitation of high wind and solar potential. It has been concluded that following the interconnection, the installation of 33.5 MW of wind and solar energy is feasible. The assumed capacity will cover the total energy demand by 2030 allowing also electricity exports to the Greek mainland. Transforming Syros into a regional renewable energy hub will contribute to the energy security, providing access to its own energy resources.

Peer-review under responsibility of KES International

Keywords: *island, interconnection, renewable energy, solar, wind*

1. Introduction

Greece is a Mediterranean country surrounded by sea possessing the largest coastline in Europe, approximately 15 thousands km. The Greek territory contains almost 3,000 islands accounting for 20% of the Greek land area. Among them, only 83 are residential areas and 28 are interconnected with the main power grid [1]. These islands are located in the Aegean Sea, with the exception of three small islands (Othoni, Ereikoussa and Gavdos). The non-interconnected islands (NII) are split in 5 different regions as follow: South Aegean including Cyclades and Dodecanese, North Aegean, Crete and Skyros Island belonging to Sporades complex of islands. According to the current plans, the majority of these islands will be connected with the mainland by 2030, even though this is an optimistic perspective, given the current economic situation in Greece.

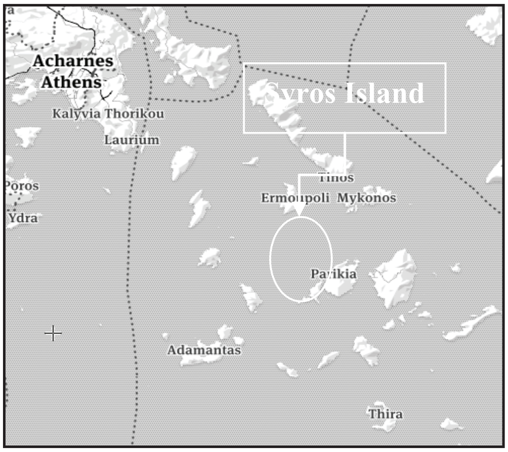

Fig. 1: Map of the Cyclades islands

Cyclades complex consist of 24 inhabitant islands, located south east of the mainland. The capital of Cycladic islands, Ermoupoli, is placed in Syros Island, at the east side of Cyclades close to the mainland (Fig.1). Ermoupoli is also the capital of Syros where the main port is located. Ano Syros is the second

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largest town located in the upper hills of the island. In this study, we focus on the current and future electrical system of Syros as it has the highest population among the rest of Cyclades islands and will be interconnected with the mainland by the end of 2016, allowing further exploitation of Syros's renewable energy potential.

Syros has 21,507 citizens and is categorized as a medium sized island, with an area of 84 km^2 [2, 3]. In general, mild temperatures are recorded, yet winters are characterized by strong winds and humidity while summers are hot and dry [4]. It has a relatively rough terrain consisted of mountains and valleys whilst the maximum height is approximately 440 m above the sea [5]. It is surrounded by other islands as: Gyaros, Kythnos, Serifos, Sifnos, Paros, Naxos Mykonos and Tinos. The island's economy is based principally on tourism alongside agriculture. Syros has also a limited industrial sector as it operates a shipyard.

Syros's power generation presents smooth fluctuations over the years according to Fig. 2. Electricity production experienced increase until 2002; however this was eliminated by 2004. From 2005, power generation recorded slightly increasing trends and was gradually stabilized by 2012. In 2013, 10% decline is presented, compared to 2012, attributed mainly to lower levels of tourism. Renewable energy becomes evident mainly after 2009 (with 4.8% share in the total energy generation). RES penetration enacted by laws: 3468/2006 and 2851/2010 which focused on accelerating renewable energy in Greece. A gradual growth until 2013 was recorded where it reaches 8.2% share of the total power generation. Although Syros has an outstanding wind and solar potential, so far, renewable energy integration is limited due to technical and economical constraints which inhibit the implementation of large scale RES projects. The average monthly energy demand profiles between 2009 and 2013 are shown in Fig. 3. During the summer months, due to the increased number of tourists, Syros island' power system requires additional loads to meet the demand required. This increase poses threats to the stability of Syros' power system resulting in occasional power cuts. Electricity demand is met mainly by the oil-burning Autonomous Power System (APS) located on the island and renewable energy resources complimentary.

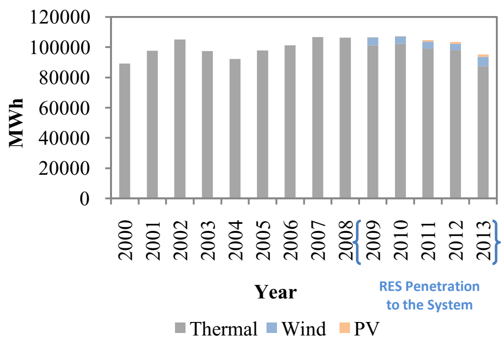

Fig 2: Power generation from 2000 to 2013 in Syros Island [6, 7]

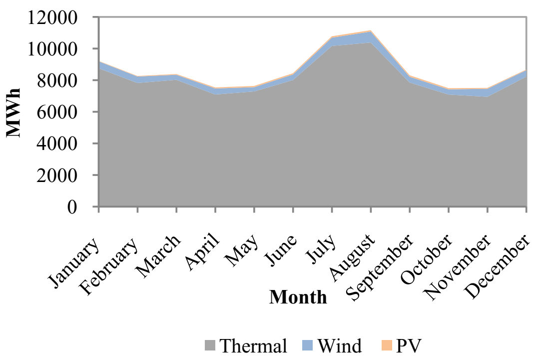

Fig. 3: Average monthly energy demand profiles from 2009 to 2013 in Syros Island [6]

Syros will undergo several transformations in the following years as the interconnection with the mainland (Lavrio town) as well as Paros, Mykonos and Naxos islands is already in progress. In this study, we assume that the interconnection has already taken place and we will explore the benefits of sustainable energy integration.

2. Interconnection of Syros Island with the mainland

The interconnection of Cyclades islands constitutes one of the most important projects that the Greek Power Transmission Operator (IPTO) or ADMIE has ever implemented, with several economic, environmental and social benefits for the country. The completion of the first phase of Cyclades interconnection project is scheduled for the end of 2016 and includes Syros, Tinos and Paros islands [7]. The total completion of this project has a horizon time until 2025 however, possible delays may occur during its construction. The initial study conducted by the National Technical University of Athens for the Regulatory Authority for Energy (RAE) in 2004, proposed three different scenarios for the power grid development in the area. Scenario A, suggesting interconnection of Cyclades islands (up to Paros island) expanding the existing transmission line of Evia-Andros islands while the APS continue to operate complimentary. Scenario B interconnecting Syros Island and other islands in Cyclades (in a second stage) with the national grid system through a new line suggesting closure of the APS. Finally, Scenario C proposed no interconnection and the development of two new APS one for Syros and Mykonos and another one for Paros and Naxos islands [8]. The most efficient scenario in terms of grid stability, environmental impact and economic cost was found to be Scenario B, described in the following paragraphs [9]. This interconnection has to be in parallel with renewable energy development in the region as this is the main incentive for interconnections implementation.

The total cost of the project is approximately 391 million Euros, while phase A will cost 251 Million Euros. The annual operation cost is estimated to be 1.3 million [7]. Only Syros interconnection will cost 115 million Euros. Notwithstanding the high costs, the economic benefits from the gradual shut down of the majority of the APS on the islands and the installation of approximately 200 MW of RES, is more than 2 billion Euros. The avoided environmental costs are projected to be 250 million Euros until 2038. The socio-economic analysis showed that the Net Present Value (NPV) is between 341 and 371 million Euros and the Investment Rate of Return (IRR) is 17.87% between 2017 and 2038. These two factors prove that this project is exceptionally profitable for the upcoming decades [7].

Cyclades Interconnection is divided in 3 phases [10]:

Phase A

a. Syros will be interconnected to Lavrio's substation in the Greek mainland, with a pair of submarine cables, 108 km length, with the following features: three phase AC power cord, transmission voltage 150 kV and nominal capacity 200 MVA each, with plastic insulation in simultaneous parallel function.
b. Syros with the northern part of Tinos (already interconnected with the mainland), with a submarine cable, 33 km length, with the same features as above.
c. Syros with Paros though a 46 km length radial connection with a submarine cable, with the following features: three phase AC power cord, transmission voltage 150 kV and nominal capacity 140 MVA, with plastic insulation.
d. Syros with Mykonos through a 35 km length radial connection with a submarine cable with the same features as the previous connections.

Through this interconnection all the above islands will be interconnected with the mainland and will allow renewable energy investments equal to approximately 170 MW under N conditions and until 120 MW under N-1 conditions (in case the cable Syros-Lavrio is damaged). Gas Insulation Substation (GIS) will be constructed in Lavrio, Tinos, Syros, Paros and Mykonos Islands, Static Var Compensator (SVC) inductors will be placed in Syros and an inductor and a capacitor will be installed in Paros [10]. In the islands' land area, new grid installations will be underground in order to avoid natural and aesthetical disturbance.

Phase B

This phase includes further expansion of the interconnections with a submarine cable (three-phase AC power cord transmission voltage 150 kV and nominal capacity 140 MVA, with plastic insulation).

- Paros and Naxos will be interconnected (7.6 km and capacity of 150 kV)
- Naxos will be connected with Mykonos (40 km and capacity 150 kV)

Phase C

This phase includes reinforcement of the grid constructed in Phase A. The upgrade of the network will include the immersion of a second AC cable between Lavrio and Syros.

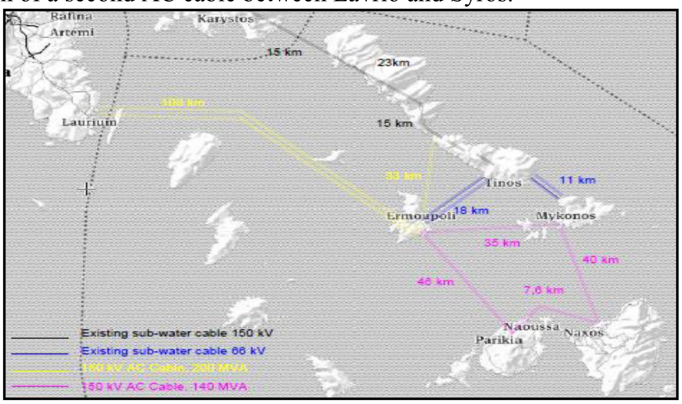

Fig. 4: Interconnection of Cyclades islands

3. Renewable energy penetration following the interconnection

3.1. Current situation in Syros Island

Currently, solar energy capacity is 1.59 MW and wind capacity is 2.84 MW. In the island of Syros two types of solar installations are implemented:

- 14 small PV parks constructed on the ground, with capacity between 20 kW and 150 kW, spread across the island with a total capacity of 893.78 kW [11].
- 216 PV systems integrated on buildings' roofs (usually 5 kW/installation) with a total capacity of 702.52 kW [12].

Solar energy was mainly integrated after 2008 due to special subsidized schemes with high Feed in Tariffs (F.I.T.) enacted by Laws 3468/2006 and 3851/2010. As a result of the financial crisis in Greece, in 2013 these two legislations were amended, by decreasing F.I.T. to approximately 1.1* System Marginal Price (SMP)* for future PV projects [13, 14].This has brought cancelation of several scheduled projects.

Wind energy was initially integrated in Syros network in 2006, with the installation of a 200 kW wind turbine. Later on, a larger wind farm of 2.64 MW was implemented in 2009 [15]. Due to wind power intermittency which results in large curtailments, wind generation shouldn't go above the limit of 30% of the hourly load demand in order to ensure N-1 criterion [16, 17]. By assuming that the island is interconnected, wind generation will be transmitted to the system under the main network regulations without the implications of such restrictions. Including the fact that F.I.T. for wind power didn't suffer important reductions, as the wind energy price is close to the SMP, wind power exploitation has significant potential in the island. This will be discussed in the following sections.

3.2. Potential Renewable Energy Capacity for Syros Island

Syros currently operates an Autonomous Power System (APS) which consists of 11 units with a total capacity of 39.7 MW. Fig. 5 shows two scenarios (Low and High) projecting an increase in energy demand by 23.5% (LS) and 34% (HS) respectively for 2030 compared to 2013. Once Syros is interconnected (phase A), the use of the current oil fired power station will be gradually eliminated and replaced with power transmissions from the main system based primarily on natural gas. Syros, will become interconnected through Lavrio and through Tinos and Evia islands. Although the two different interconnection cables provide a more stable power system from the first stage of the project, the power transmission capacity is merely 120 MW, imposing Syros to operate the APS in case of higher loads until the completion of phase C.

The estimated sustainable energy development (principally wind) in the interconnected islands of Cyclades is expected to be 150-200 MW [10] while the total development after 2027 in both non and interconnected Cyclades islands will exceed 250 MW [7]. Drawn from this projection, we propose to meet significant amounts of future energy loads from high renewable energy integration in Syros' power system.

According to the data collection analysed before, and the current infrastructure of the Greek electricity sector two potential types of renewable energy resources were identified for Syros: solar and wind. Other forms of energy such as geothermal power is not identified on the island as Syros posses no geothermic potential [18].

Concentrated Solar Thermal (CST) or Concentrated Solar Power (CSP) is an emerging technology which is currently being extensively commercialised around the world. Although, this technology is much more efficient compared to photovoltaic technology it is preferable in southern locations (e.g. Crete, south Rhodes) and is not recommended for Cycladic islands as the solar potential is not adequately utilisable [19]. Additionally, CST installations require large areas of land in order to be implemented and cannot be integrated in buildings unless its use is limited as water heaters.

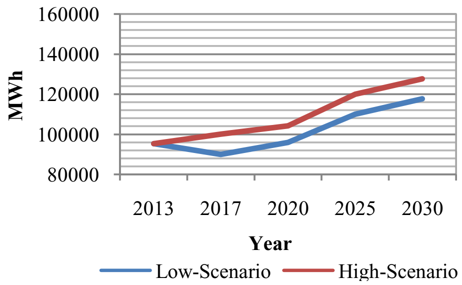

Fig. 5: Projected energy demand in the island of Syros [7]

* The System Marginal Price (SMP) is the lowest cost of power from any available producer.

3.2.1 Potential Wind Energy Capacity for Syros Island

Fig. 6 illustrates very high wind potential for Syros, showing wind speed more than 12 m/s (in 100 m height) in the northern and southern part of the island while Syros is characterized as a highly suitable zone for wind energy investments among other areas in Greece. Fig. 7 illustrates the existing and licensed wind projects on Syros map. Wind Projects are categorized as:

- Already implemented, blue color - of total capacity 2.84 MW.
- Licensed projects, yellow color - of total capacity 4.2 MW.
- Under consideration, magenta color - of total capacity 8MW

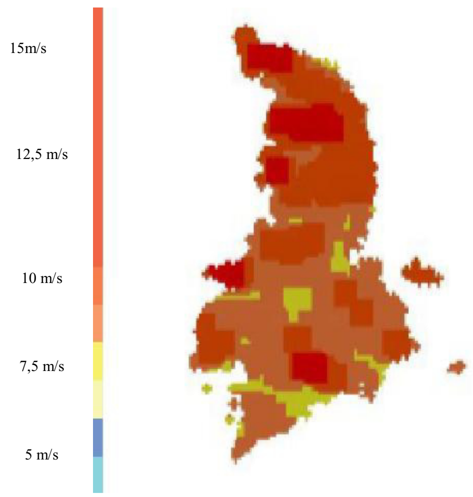

Fig. 6: Map of wind potential for the island of Syros [15]

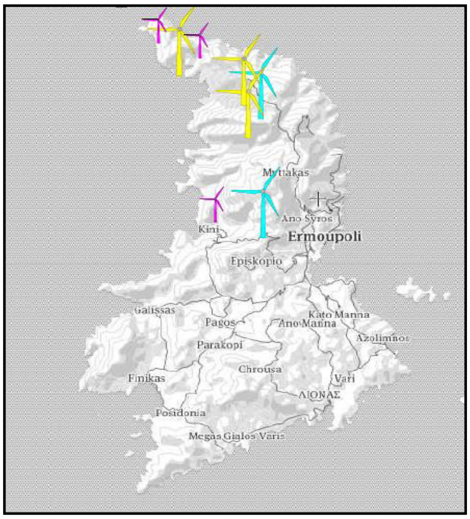

Fig. 7: Map of existing and licensed projects in Syros

By combing both Fig. 6 and Fig. 7 is evident that a number of windy areas on the island have already been occupied by installed or licensed projects. However, several other spots with high wind potential are identified. Although, high wind speed is an essential requirement for wind energy projects, their suitability is subject to several additional criteria. Some examples are: visual impact, land value, slope of the area, land use, distance from electricity grid and distance from roads [20].

The maximum limit of wind installations in Syros Island is estimated to be 30 MW. This is because of its small-medium size, the relatively high population (255.8 p/Km^2), cable's transfer capacity and the average wind potential compared to other islands. So far, 7.04 MW projects have acquired licenses consisting of 6 typical wind turbines (W/T). According to RAE, the maximum number of typical W/T[†] which can be installed on this island are 36, which means that the existing licensed projects cover 16.67% of the allowed number [21].

3.2.2 Potential Solar Energy Capacity for Syros Island

Fig. 8 shows the solar irradiation of Syros. As in most Greek locations, annual global irradiation exceeds 2000 kWh/m^2 during the summer months. However, the rough terrain alongside limited land areas and traditional architecture on the island do not favor large scale PV projects. Two Solar Parks, 100 kW each, are awaiting positive response from RAE as well as 4 licenses for building installations (approximately 5 kW each) [11]. These projects are unlikely to be constructed under the current low F.I.T., although roof installations may be integrated in other legislation frameworks such as the "Net-Metering Policy".

[†] A typical wind turbine has a rotor diameter equal with 85m [25]

"Net-Metering" is introduced through a new legislation framework, established by a final ministerial decision in 2014 [22], which will give the chance to every property owner (residential, commercial or industrial) to install PV roof systems with an upper limit of 10 kW as long as the island is not interconnected. Following the interconnection, the limit becomes 20 kW or even more, depending on the purpose and the use of the building. The owner/user of the PV installation will offset the power generation from the solar panels and the consumed energy from the in-house activities. This legislation framework aims to exempt consumers from the responsibility to pay electricity bills and enhance decentralized energy generation.

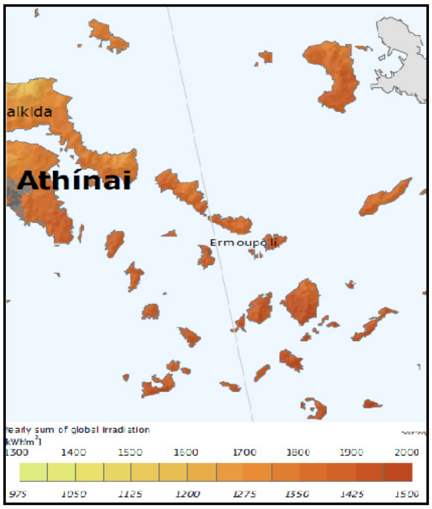

Fig. 8: Map of the yearly sum of global irradiation for the region of Cyclades [23, 24]

4. Case study- Integration of renewable energy projects following the interconnection of Syros Island.

The renewable energy scenario employed for Syros has a projection horizon time until 2030 and proposes the following:

- Wind energy capacity increase to 30 MW
- Solar energy boost in the tourism sector along with residential/commercial building installations in order to reach 3.5 MW in total.

4.1. Wind Energy Growth

Regarding wind energy the following assumptions are made:

a. Implementation of projects which have already acquired licenses.
b. Replacement of old W/T or part of them, passing their 20 years lifetime.
c. Further development of additional 15 MW in order to reach the target of 30 MW

Table 1 presents data and assumptions regarding already constructed or licensed projects along with characteristics related to the wind turbines and the location of the project.

- Projects 1 & 2 are connected and have been operating for 9 and 6 years respectively. By 2027 and 2030 they will have to be replaced with new, more advanced W/T technology.
- Projects 3, 4 & 5 have acquired production licenses and are in the stage of environmental licensing.
- Project 6 split in three locations, is currently assessed by RAE in order to obtain a license.

The wind speed of every location in order to estimate the annual energy production in Table 1 was taken initially from Fig. 6 in 100 m (z_1). As the hub heights of the wind turbines (z_2) are significantly lower than 100m, the average wind speed (v_2) was calculated from the following equation (Eq. 1), according to every project's specifications, assuming a mean wind shear in the wider area of $\alpha=0,15$.

$$v_2 = v_1 \left(\frac{z_2}{z_1}\right)^a$$

Eq. 1: Power Law Equation [26]

Additional data for wind turbine types was not provided. Estimations for energy production derived from various W/T models (using their power curves in relation to the average wind speed) with large scale commercial application in the Greek wind energy industry. The equation for energy production calculation is given by:

$$EP = C * e * h * n$$

Eq. 2: Average Annual Energy Production

Where

EP: Average Energy Production / installation
C: Energy produced in correlation between power curve and wind speed (v_2)
e: average losses due to W/T availability (3%), Density of wind (3%) and Transmission losses through the grid and substations (8%)
h: annual hours, *n:* number of W/T

Table 1: Characteristics of existing, licensed and under evaluation wind projects in Syros ‡

	Capacity (MW)	Number of W/T	Capacity per W/T	Connection Date	Estimated Connection Date	Location	Avg. Wind Speed (m/s)	Avg. Annual Energy Pr. (MWh)
1	2.64	4	0.66	2006		Syrigas	10.82	14,147.00
2	0.2	1	0.2	2009		Voulias	9.95	828.70
3	1.2	2	0.6		2017	Syrigas	10.46	2,144.63
4	0.6	1	0.6		2017	Halara	10.46	2,144.63
5	2.4	3	0.8		2017	Mavrorgios	10.97	13,560.48
6	8	10	0.8		2019	Prianas, Paniavle-Stoxinas,Pyrgos	10.24	37,668.00
Total	15.04	**21**						**70,493.43**

Table 2, presents projections of 18.6 MW new wind farms implemented gradually after the interconnection, following the previous methodology and by including the replacement of old projects with new wind turbines. Based on these we assumed:

- New wind turbines of 0.9 MW and 2 MW capacity, instead of 0.6 MW and 0.2 MW that were previously used
- No significant changes in the hub-height of old W/T
- The number of replaced W/T remained the same as we considered that is was predetermined under environmental and configuration regulations.
- The total number of wind turbines will be 36, equal to the maximum limit according to RAE
- Max distance from roads (10km) & Min distance from residential areas e.g. towns, villages (500m) [25]
- Appropriate arrangement of W/T: (distance from blade to blade 2.5 D§, distance from blade to the edge of the arranged installation polygon 1.5D) [25]

In order to identify appropriate locations we used four different types of maps:

a. Touristic map for archaeological sites, beaches and areas of high touristic interest.
b. Physical/Road map for identifying public areas, areas of environmental interest and the terrain
c. A thematic map provided by RAE which shows all the existing and licensed RES projects
d. A wind potential map in order to recognize unexploited areas with related interest

Based on the above assumptions we proposed the following projects, illustrated also in Fig. 9.

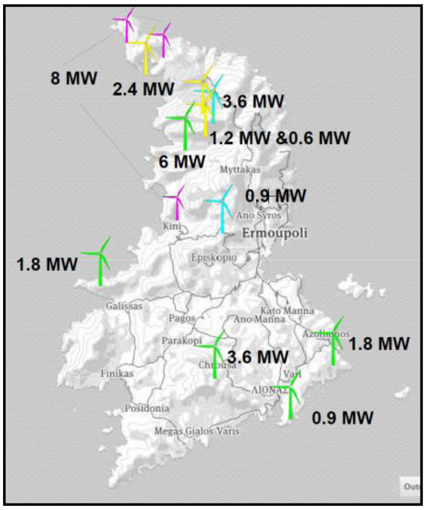

Fig. 9: Map with constructed, scheduled and future projects

‡ Information for the projects found in [15, 27]
§ D is the rotor diameter

Table 2: Characteristics of future wind projects in Syros

	Capacity (MW)	Number of W/T	Capacity per W/T	Estimated Connection Date	Location	Avg.Wind Speed (m/s)	Avg. Annual Energy Pr. (MWh)
1	3,6	4	0,9	2021	Chrousa	10.97	18,080.64
2	0,9	1	0,9	2023	Ormos Varis	7.98	1,770.39
3	1,8	2	0,9	2024	Akr. Katakefalos	10.06	6,930.91
4	1,8	2	0,9	2027	Akr. Fokia	7.96	3,510.66
5	0,9	1	0,9	2027	W/T Replacement - Voulias	10.65	3,503.12
6	3,6	4	0,9	2030	W/T Replacement - Syrigas	10.97	14,163.16
7	6	3	2	2030	Chalara	11.71	43,280.53
Total	**18,6**	**17**					**91,239.43**

4.2. Solar Energy Growth

Emphasis is placed on building installations mainly in the tourism sector, being the main sector for Syros' economy. Syros has 9112 buildings [28], and several of them are hotels, or rooms to let. In that sense, information was collected considering the majority of Syros' accommodation for tourists. We categorized Syros' hotels according to their size as follow:

- small sized hotels (1-19 bedrooms)
- medium sized hotels (19-49 bedrooms)
- large sized hotels with more than 50 bedrooms
- mega sized hotels with more than 100 bedrooms

This scenario, aims to transform a large number of Syros' buildings in autonomous consumers-producers based on the following assumptions:

- PV installations will be integrated in the 'Net-Metering' scheme. As it is already mentioned, it puts a limit to 20 kW per installation. For installations of more than 20 kW, there is a limit of: PV capacity < 0.5 contracted capacity from electricity grid [29].
- Cyclades islands have a unique architecture which should not be disturbed by large PV installations. Taking into consideration that, we considered 10 kW for small hotels and we increased that to 20 kW for medium sized businesses.
- In Ermoupoli, because of the exceptional historical buildings which characterize the capital of Cyclades islands, PV installations are limited to 7.5 kW for small hotels and 15 kW for medium.
- PV panels have to be placed with no inclination and sometimes thin-film technology is preferred in order to assure no optical vision.
- The average energy production per kW was estimated based on the PVGIS calculator provided by the Joint Research Centre of the European Commission for the location of Syros–taking into consideration the above assumptions [30].

Inputs in the calculator are included in Table 3 and the estimated energy production per kW was 1380 kWh.

Table 3: Inputs for Syros PV installations in PVGIS Photovoltaic Calculator

Location: 37°25'49" North, 24°54'56" East, Elevation: 134 m a.s.l.,
Solar radiation database used: PVGIS-CMSAF
Nominal power of the PV system: 1.0 kW (crystalline silicon)
Estimated losses due to temperature and low irradiance: 12.9% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 3.1%- Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 27.4%- No slope

Table 4: Number of hotels and PV installations based on the building size

Number of Hotels	Location	Size of the Hotel/Rooms to let	Future Capacity Installed(kW)	Total (kW)	Average Annual Energy Pr.(MWh)
4 hotels	Ermoupoli	Medium	15	60	82.80
16 hotels	Ermoupoli	Small	7	112	154.56
1 hotel	Galissas	Mega	50	50	69.00
2 hotel	Vari	Small	10	20	27.60
3 hotels	Vari	Medium	20	60	82.80
5 hotels	Foinikas	Small	10	50	69.00
9 Hotels	Galissas	Small	10	90	124.20
5 hotels	Galissas	Medium	20	100	138.00
4 hotels	Posidonia	Small	10	40	55.20
5 hotels	Kini	Small	10	50	69.00
1 hotel	Azolimnos	Large	50	50	69.00
4 hotels	Azolimnos	Medium	20	80	110.40
7 hotels	Azolimnos	Small	10	70	96.60
Total				**832**	**1148.16**

In Ermoupoli town as the capital of Syros and of Cyclades region are located several public and commercial buildings. Therefore, we considered a scenario where we assumed to install PV installations on the major public buildings (town hall and public library). Also we assumed 10 kW PV installations in all banks. Regarding the rest of the buildings, we estimate the installation of at least 900 kW, approximately equal to the already existing residential and commercial building installations. In total, this case provides to Syros almost 3.5 MW or 4,830 MWh of clean solar energy per year.

Table 5: Public buildings and PV installations based on the building size

Public Building	Location	Type of Buiding	Future Capacity Installed (kW)	Total in all (kW)	Average Annual Energy Pr. (MWh)
Town Hall	Ermoupoli	Very Large	50	50	69.00
Library	Ermoupoli	Large	20	20	27.60
8 banks	Ermoupoli	Medium	10	80	110.40
Total				**150**	**207.00**

5. Discussions

Fig. 10 shows within five years steps the transformation of Syros' power sector, following the interconnection. The level of renewable energy share is presented in Fig. 11, which proves that the total electricity generation both from wind and solar could reach 151,587.16 MWh and cover 100% of the that total energy demand in both scenarios in 2030 (Fig.5) and also allow power exports to the national grid system. By 2030, Syros will export annually almost 29 MWh in the Low Scenario (LS) and 19 MWh in the High Scenario (HS), transforming Syros into a renewable energy hub. This amount of clean energy is equal to avoided emissions in 2030 of 57,754.7 $tnCO_2$ in case natural gas is the main power source (after the interconnection) and 134,609.4$tnCO_2$, in case the interconnection was not implemented and heavy oil and diesel power generators continued their operation according to IPPC methodology [31].

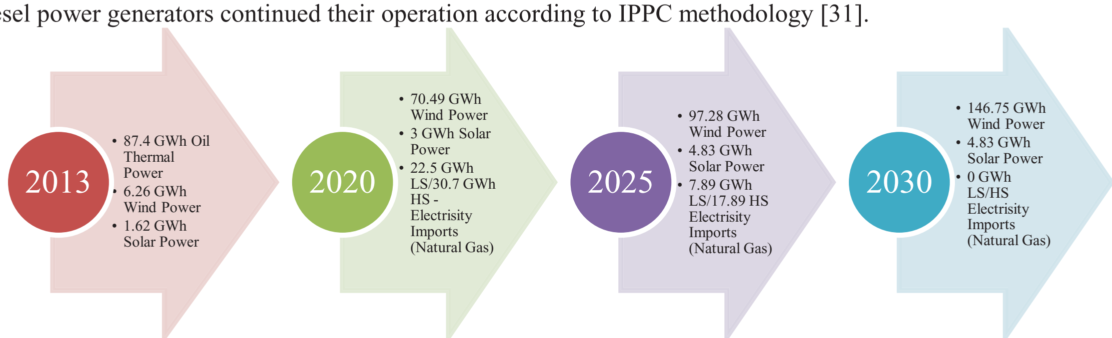

Fig.10: Outline of RES integration in Syros Island from 2013 to 2030

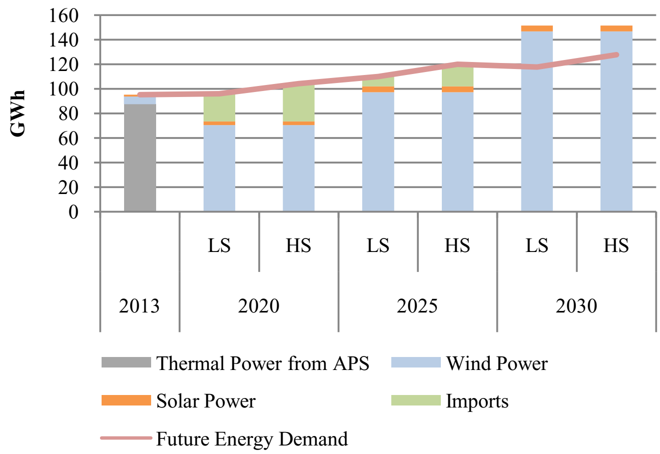

Fig.11: Average power generation percentages by source for Syros Island for Low and High energy demand scenarios (LS/HS)

These renewable energy projects will contribute to the national and European targets for emissions reduction for 2030 which was recently established as: 40% reduction in carbon emissions (compared to 1990 levels), 27% integration of renewables and energy savings [32]. Greece needs such large scale renewable energy projects as it is still behind in emissions reduction compared to other EU members. Moreover, these projects will reinforce the local and national economy and will offer several work opportunities during the stage of construction, maintenance and for security purposes.

6. Conclusions

The island of Syros has exceptional wind and solar potential which will be exploited following the scheduled interconnection within 2016. In this paper, we employed a scenario of 30 MW wind farms and 3.5 MW of solar installations by 2030 including already licensed, under evaluation, as well as new wind and solar projects. In order to identify suitable locations on the island for wind installations we took into account several technical and environmental factors. For solar installations we placed emphasis on the current policies as well as practical issues (space, economy and aesthetics). The proposed scenario underlines the fact that a transformation of a Greek island to a renewable energy hub (100% RES) is feasible with the precondition to become interconnected (otherwise energy storage technologies will have to be employed). Interconnection and RES integration will bring to the local society and the national energy market multiple benefits, although there are still challenges and limitations, which have to be addressed.

In this current study, we placed a limit of 30 MW of wind farms due to technical constraints imposed by the transferred capacity of the cable as well as the limited areas on the island. Additional wind farms can only be implemented by upgrading the capacity of the grid as well as exploiting wind offshore opportunities, which at the moment are not permitted by the Regulatory Authority for Energy (RAE) in Greece.

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